Charm Reconstruction with a Heavy-Flavor Tracker for STAR

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Lattice calculations of QCD predict that at a critical temperature of $T_c \approx 170$ MeV, corresponding to an energy density of $\varepsilon_c \approx 1$ GeV/fm^3, a phase transition of ordinary nuclear matter to a deconfined state of quarks and gluons occurs. In ultra-relativistic nuclear collisions, such as those at the Relativistic Heavy Ion Collider (RHIC), energy densities are expected to reach and even exceed the critical energy density ε_c. In general, the development of collectivity at the partonic level (among quarks and gluons) and the degree of thermalization are closely related to the equation of state (EOS) of partonic matter.

Measurements of elliptic flow in 200 GeV Au+Au collisions at the RHIC have demonstrated the collective flow of partons, or partonic collectivity. To pin down the partonic EOS at RHIC, one must address the status of thermalization in such collisions. Since the masses of heavy-flavor, charm quarks for example, are much larger than the maximum possible excitation of the system created in the collision, heavy-flavor collective motion could be used to indicate the thermalization of light flavors (u-,d-, s- quark hadrons). In order to measure the low p_T v_2 of charmed hadrons at RHIC, we propose to construct a heavy flavor tracker (HFT) for the STAR experiment at RHIC [1].

We performed detailed studies on the expected performance of this new sub-detector in STAR (see Fig. 1). These studies included Monte Carlo simulations taking into account the detector geometry, realistic response functions of all sub-detector systems and a full tracking algorithm. From reconstructed tracks of charged particles, we applied a search algorithm to identify charmed mesons through their invariant mass in selected hadronic decay channels, e.g. $D^0 \rightarrow \pi + K$. Geometric and topological cuts were chosen to optimize the statistical significance in D^0 meson detection using the program package MINUIT.

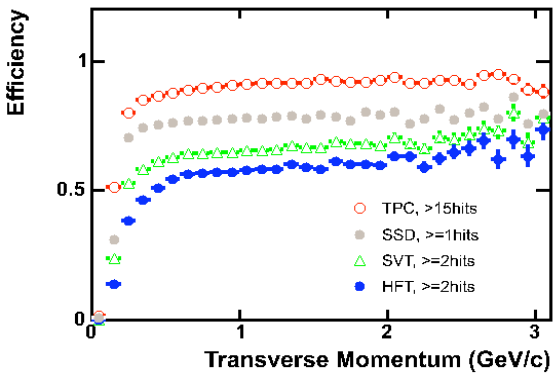

FIG. 1: Reconstruction efficiency for charged tracks in the STAR detector.

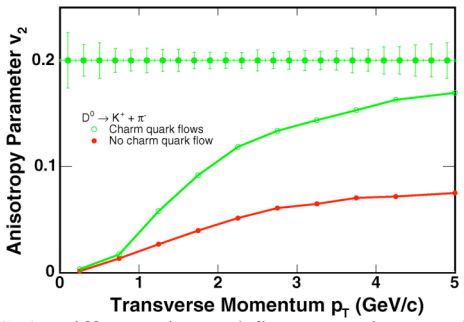

FIG. 2: Different charmed flow scenarios, consistent with flow equivalent to that of lighter flavors, and no flow. Flow of charm requires significant rescattering; zero flow would provide an upper bound to the degree of rescattering in the parton phase and thermalization of the system. Expected statistical errors from one year of running at RHIC (Run IV conditions) are shown along the top curve, and they are sufficient to resolve the two possible states.

Figure 2 shows the estimated statistical uncertainties in the elliptic flow measurement of D^0 mesons within the first year of data taking. We assume 50 M central Au+Au collisions, a number already achieved in last year's run IV at RHIC. At low momentum, the statistical uncertainties are dominated by the rather low reconstruction efficiency for D^0 meson due to the selected decay length cut of 200 μm. A minimum is reached around 2 GeV/c where the reconstruction efficiency saturates. At larger momentum, the uncertainties are dominated by the exponentially decreasing yield of D^0 mesons.

The solid lines present predictions from model calculation assuming no charm quark flow (red) and full charm quark flow (green). Within these estimated uncertainties, the two extremes of charm quark dynamics can be clearly separated.

The precise measurement of heavy quark elliptic flow addressing light quark thermalization is maybe the final step necessary for a QGP discovery. The proposed Heavy Flavor Tracker at STAR is well suited for achieving this goal.

REFERENCES

[1] Z. Xu *et al.*, *A Heavy Flavor Tracker for STAR*, Proposal to the STAR experiment , LBNL/PUB-5509 (2005).